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Performance Analysis of Hierarchical Location Management Scheme to Locate Mobile Agents

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Abstract: A Mobile Agent (MA) is a computer program that takes action autonomously on behalf of a user and moves in the heterogeneous communication environment. Once MA is initiated, its inventor has no control over it and has no information about its location. The location of MA must be traced to communicate with MAs and a suitable communication mechanism must be used. Lots of research has been done in the literature but these are not enough to get the actual location of MA efficiently and accurately. This paper models the novel region based Hierarchical Location Management Scheme (HLMS) for Mobile Multi Agent Environment that has been already proposed by authors in previous works. A mailbox based communication mechanism has also been proposed among the MAs. MA carries this mailbox with it or may leave it on some place. Any MA wants to communicate with other will drop the message to the mailbox. MA then gets the message by using pull or push approach. This paper identifies the variety of components of HLMS and models it using Color Petri Net (CPN) tool. After building the model, various tools provided by CPN such as monitoring, state space and user controlled simulation have been used to check the correctness of the modelled system. The different features of CPN tool like monitor, Mark-up Language are then used to collect the data to check the performance of the HLMS against various parameters such as Migration Probability (intraregional or interregional), Search probability, Trip Time etc .

Keywords: Hierarchical Location Management Scheme (HLMS), Location Management System (LMS), Color Petri Net (CPN) tool.

I. INTRODUCTION

A mobile agent (MA) is a software procedure that workings on behalf of user/application with the capability to travel starting one host to different host under its own control in the open network like internet. For some applications, instead of one Mobile Agent, group of mobile agents are launched. These MAs are executed independently across the network but often required to cooperate with each other, to identify the position of each other and to share data/partial results. MAs interacting with each others may be launched by same user or by different users. Such system of coordinating and cooperating agents is often termed as Mobile-Multi-Agent System (MMAS) [1, 2, and 3].

Once a MA is launched its creator has no control over it and has no information about the location of MA until it comeback to the creator after completing its itinerary. Locating and communicating in real time is one of the major research area related with MA. This paper discusses in brief the proposed location management scheme and its modelling by using CPN. Paper discusses in detail the performance analysis of proposed scheme based on simulation through model.

II. HIERARCHICAL LOCATION MANAGEMENT SCHEME

Our work is inspired by [4, 5, 6, 7, 8, and 9]. All these approaches divide the network into regions. In-charge of each region keeps track of all MAs in its region. Regions may be in one, two or multiple levels. Internet is network of networks where networks are connected with each other via routers. Hierarchical Location Management Scheme (HLMS) uses this characteristic of network to represent regions. Fig.-1 shows the system model for HLMS.

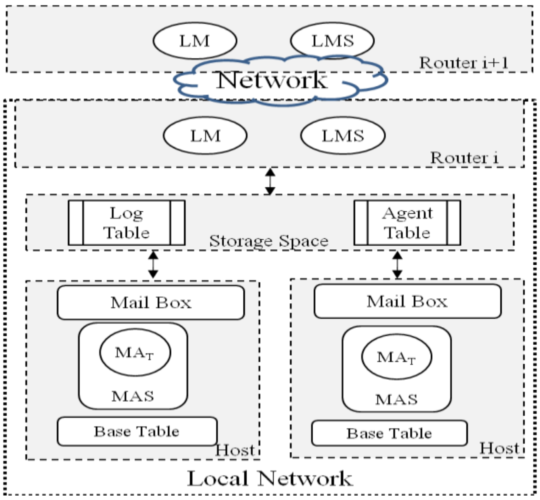

Fig. 1. System Model for HLMS

Each router maintains an ***Agent Table*** (AT) which holds all the MAs currently performing on the network and their ***Host Id***. It also maintains a ***Log Table*** (LT) to record the arrival and departure entry for each MA arriving and leaving the network. Each host maintains a ***Base Table (BT)*** to keep records of each MA created by it and its current ***Network Id***. At each router Location Management System (LMS) is installed to accomplish all location

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related activities. Location Manager (LM) part of LMS installed at router is responsible to take decisions. HLMS combines search and update based location management schemes to find MAs in the global network. When a MA shifts from one host to other within the same network AT is updated.

When MA shifts from one network to other, receiving router initiate an ***Update Agent*** (UA) to notify the BH about the new network location of the MA and BT at base host is modified**.** So in this method BH always knows the current network of its MA. To communicate with MA, BH forwards the message to the router of MA, where router locates the MA by searching the AT and delivers the message. Meanwhile if MA has migrated from the network, components installed at router are responsible to locate MA by checking departure entry in the LT and forward the message [10][11].

III. MODELLING OF HLMS WITH CPN

Colored Petri Nets (CP-nets or CPNs) is a graphical language for creating models of parallel systems and investigating their properties. To model the HLMS, primary the different structure of components are identified and then different tokens for the system are documented. Various color-sets are used to signify various tokens and place types. Identified places and tokens are then placed in various pages and pages are arranged in hierarchy according to the nature of the system. Various user defined functions are then developed to model complex characteristics of the HLMS. Table-1 lists the different components of HLMS for Mobile Multi Agent environment and their descriptions.

TABLE 1. COMPONENT DESCRIPTION OF HLMS

Components	***Description***
NetId	Every network is identified by a unique address ***NetId***. For modelling purpose it has been assumed that it is a single digit integer value from 1 to 9.
Agent Id	Each MA is recognized with unique id ***AgentId***. It is assumed to be a number between 11 to 99.
HostId	Every host of global network is identified by a two digit number, first digit identifies its Network and second digit identifies the host within the network.
Mobile Agent	MA is the entity moving across the network. It carries with it the list of visiting hosts, list of visited host, its ***AgentId***, and list of ***AgentId*** with their Base ***HostId*** for communication. Here the creation time is also assign with the MA.
Search Agent	It is a MA launched to search the BT or AT to get ***NetId*** or ***HostId*** respectively.
Update Agent	It is also a MA which is launched to update the ***NetId*** in the BT.
Packet	MA travel from one part of the network to other via global network in the form of packet. A packet contains an Agent, sender ***NetId***, destination ***NetId*** and type of agent (MA, SA, UA, SMA, SHA, SNA, RNA or RHA) and some additional information such as current ***NetId*** and ***HostId*** of MA.
Base Table (BT)	Every host preserves a BT, which keeps the list of ***AgentId*** and the current ***NetId*** of the MA launched by the host.
Agent Table AT)	Every network keeps an AT, which is the list of ***AgentId*** and ***HostId*** currently executing the MA.
Log Table (LT)	Every network maintains a LT which contains the ***AgentId*** and Timestamp for all MAs arriving and leaving the network.

For modelling of HLMS, various assumptions have been made to simplify the real complex network environment. These assumptions are not a restriction to the proposed algorithm but only simplification for the modelling.

A. *Network Description*

A hierarchical CPN has been used to model the HLMS. The model uses some fusion places and substitution transitions as well. The subsequent segment explains the design and working of every stage of the hierarchy. Fig. 2 shows different pages and their hierarchy.

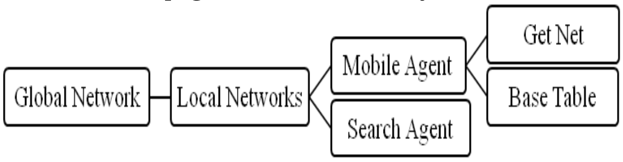

Fig. 2: Network Description of HLMS

1) Global Network

This network sheet is used to form the global network through which packets are stimulated from single network to a different. Every network is sub-page of this sheet and applies it to send/receive Agents. Packet broadcast time depends on the type of Agent transferred [10].

When any component of the system wants to send some entity across the network, it first creates a packet and then places the packet at fusion place ***SentPacket.*** A data at place ***SentPacket*** fires the transition Global network and packet arrives at the place ***ReceivedPacket*** after sufficient delay.

2) Local Networks

This network page models the various components and actions performed at the Router as show in Fig. 3. Its components are responsible for receiving and sending Agents. It contains two sub pages ***MobileAgent*** and ***SearchAtable***.

3) Mobile Agent Page

This page is subpage of Local Network page, which models the various actions performed when a MA is received at the Router shown in Fig. 4.

4) GetNet

This page is subpage of page Mobile Agent, which models the actions when source MA suspends it execution until it locates and communicates with target MA show in Fig. 5.

5) Search Agent Page

This page is also the subpage of Local Networks page, which models the procedure of searching a MA at the local Network shown in Fig. 6.

6) Base Table

This network page is the subpage of page MA, which maintains the BT. Entries in BT can be added, modified, deleted or searched. A new record is added in BT when a new MA is created. BT is updated when an UA is received. A record from BT is removed for every terminated MA.

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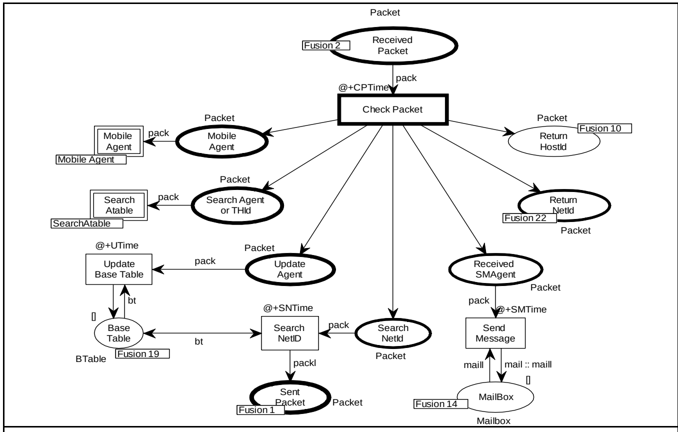

Fig. 3. CPN page modeling the actions performed at Router.

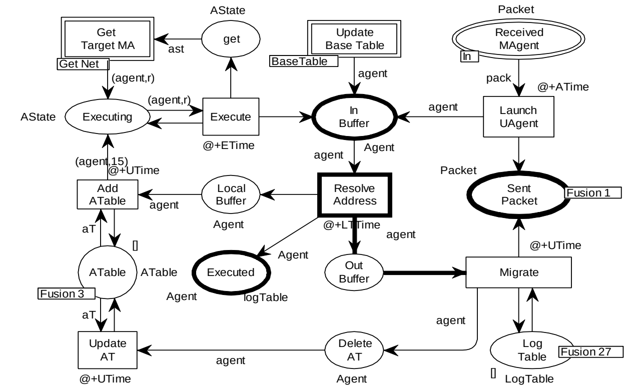

Fig. 4. CPN page modeling the Local Network

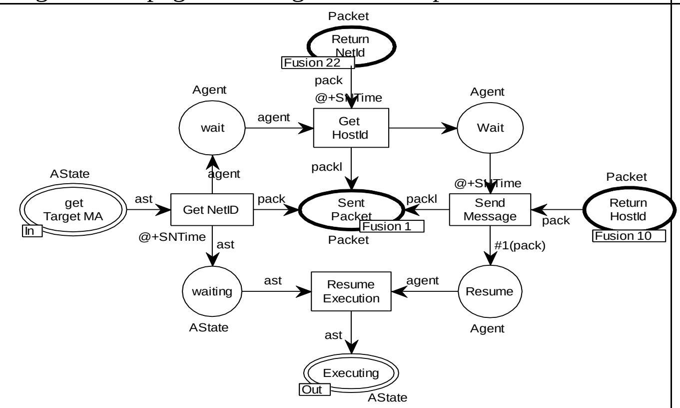

Fig. 5. CPN page modeling to initiate searching for target MA

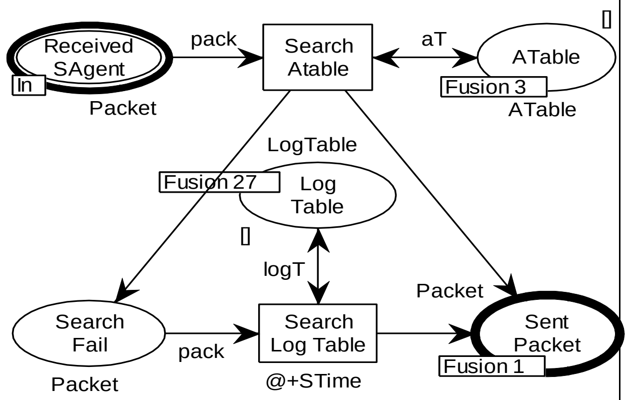

Fig. 6. CPN page modeling the search procedure at a particular network

IV. PERFORMANCE ANALYSIS

Performance analysis of HLMS has been done on the basis of simulation results obtained from CPN model of HLMS. We have used the timed CPN to model HLMS. Before starting the simulation, some parameters are required to be assumed while some are generated randomly or calculated during simulation as shown in table-2.

TABLE 2: TIME VALUES DECLARATION FOR DIFFERENT VARIABLE

S. No	Time Variable Declaration	Value Declaration
1.	Execution Time (ETime)	200 time units + Random(50)
2.	MATransfer Time in Global Network (GTTime)	90 time units + Random(10)
3.	Ack. Transfer Time in Global Network (GATime)	10 time units + Random(10)
4.	Update Base Table Time (UBTime)	20 time units+ Random(10)
5.	MA Creation Time, Search Net Id Time, Search HostId Time, LogTable Time, Search AT Time, Update Time	20 time units
6.	Arrival Time of MA, Check Packet Time, Send Message Time	10 time units

Here we assign values to some of the time based parameters before simulation starts. Time for different transitions has not been assigned as per the actual system but assigned randomly to get the trend. It has been assumed that packet transmission time to carry MA is more than other packets containing other information. Packet transmission time is independent of place, time or load of network.

The MA takes constant steps but random time to execute on any host. Most of the transitions in the model take fixed time while for real application (actual environment) time highly depends on resource availability, load, infrastructure capacity and many other random factors. The MA's itinerary contains 100 randomly selected hosts and during its execution it may initiates search for other MA for communication based on its itinerary.

B. Parameters for Performance Analysis

Before using the model to collect results, it needs to be setup for analysis and parameters also need to be identified for which model is to be used. Parameters identified for analysis are defined and discussed here.

1) Trip Time(TT):

It is the time require by a MA to complete its life cycle i.e. time lapse between the creation and termination of MA.

$$TT=CT+ (MT+COT+ET)*n$$

n : No. of hosts in its itinerary
CT : Creation Time, MT: Migration Time,
COT : Communication Time (COT)
ET : Execution Time

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Trip time of a MA which wants to communicate with other MA is delayed as it waits till the communicating MA is located and communicated, so Trip time is modified as –

TT=CT+ (MT+COT+ET)*n+ WT*m

m : No. of Search initiated)
WT : Waiting Time for Source MA.

2) Migration Probability (MP):
Migration Probability of MA has been defined as the probability of migration of MA within the same region or in different region and it is defined as follows:

MP= (Nr/n)*100%

Nr : No. of times MA migrates
n : Total no. of Migration (hosts in its itinerary)

Inter-Region MP = (Nr(g)/n)*100%
Intra-Region MP = (Nr(l)/n)*100%

Nr(g) : Migration between the networks
Nr(l) : Migrates within the network

3) Search Probability (SP):
It denotes the message exchange frequency between MAs and is defined as follows: [22]

$$\mathbf{SP = (\mathit{Ni/n}) \times 100\%,}$$

Ni : number of times MA initiates Search

4) Network Overhead (NO):
Network overhead is defined as the no. of packets transferred across the network. Packets may contain MA, SA, UA or any other information. Local message/package has not been considered under NO.

5) Communication Time (COT):
If a MA wants to communicate with other MA then it first initiates a SA, time lapse between the search initiated and the message communicated between the two MAs are termed as communication time (COT).

COT and waiting time for source MA is same for UDP architecture where MA suspends its execution till message is delivered to the target MA while for TCP architecture source MA waits till target MA is located then it resumes its execution while message is delivered to target MA using TCP communication mechanism.

C. Graph of Performance Analysis

Once parameters are identified and model is setup, simulation is repeated 1000 times through ML for different cases. Minimum, maximum and average values are then used to draw graph.

1) Case 1: Trip Time Vs Migration Probability
Since HLMS performs different steps for inter or intra region migration, it may affect various parameters of the system and performance based on the MP. Fig. 7 shows the graph between TT vs MP, while fig. 8 shows graph between Execution steps Vs MP. In HLMS, for intra-region migration there is no need to launch UA, only Agent Table is to be updated. Also MA Migration within the network takes lesser time than inter region migration. As it is clear from the graph that TT and execution steps decreases as Intra-region MP increases.

Fig. 9 and 10 shows the graph between TT and Execution Steps VS Inter-Region MP. Every time MA changes its region it has to be migrated via global network, UA is required to be launched and AT and BT is need to be updated which will increase the TT and execution steps as clear from the graph in fig. 19-10.

2) Case 2: Network Overhead Vs MP
Fig 11 shows the graph between NO Vs Intra-region MP. Network overhead decreases as intra-region MP increases. As discussed above for higher migration within the region will decrees the no of UAs launched and MA migration via Global Network and enhance the performance of the HLMS.

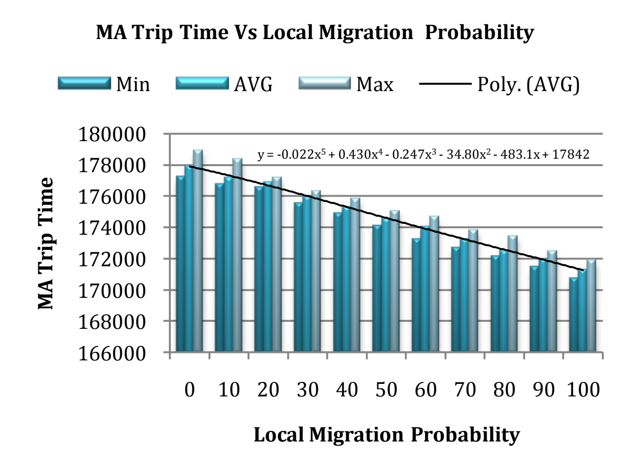

Fig. 7: Intra-region Migration Probability

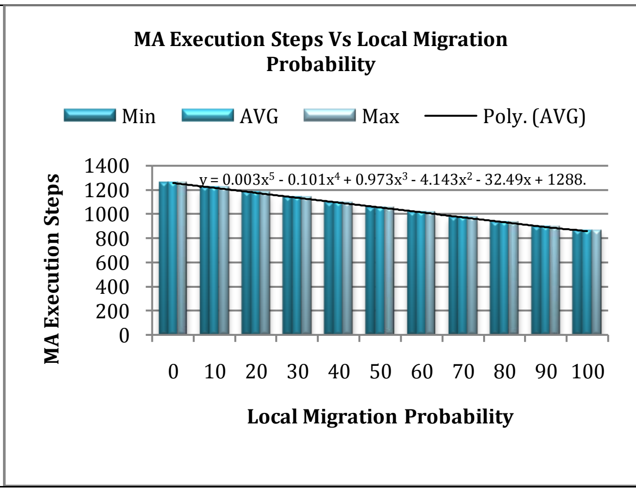

Fig. 8: Execution Steps with Intra-Region Migration Rate

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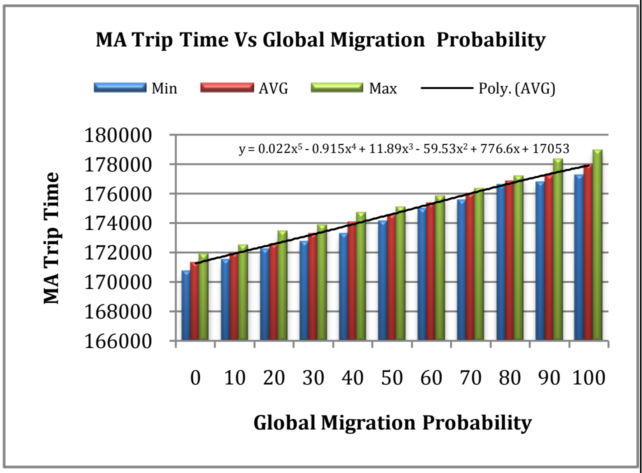

Fig. 9: Inter-region Migration rate

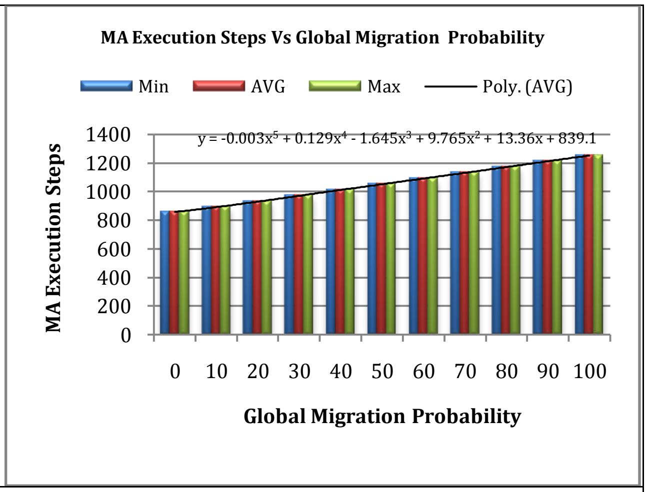

Fig. 10: Execution Steps with Inter-Region Migration Rate

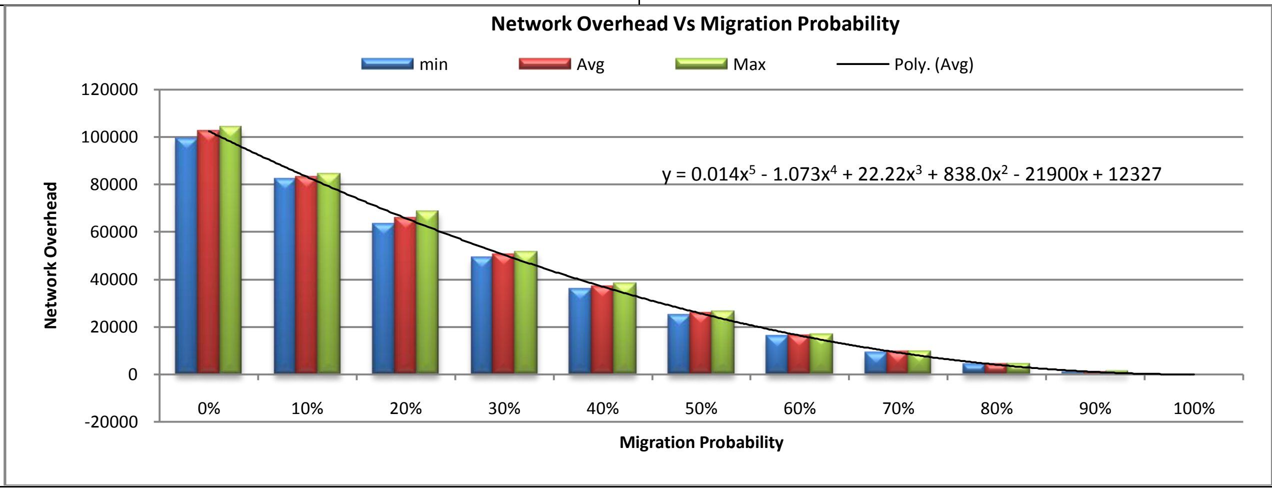

Fig. 11: Network Overhead Vs Intra Region Migration Probability

V. CONCLUSION

The verification process of the proposed protocol has been done formally using various tools provide by CPN. For running the initial simulation, the different combinations of manual binding, play and fast-forward tool has been used. Various data collector monitors were also been used to gather statistics and to check certain properties of the model. State Space tool has been used to generate the report and check the properties and correctness of all modeled components.

HLMS has been proposed which joins both search and updates and also applies router as a lively apparatus to enlarge the performance. The HLMS can be fruitfully used for both situations where only BH needs to locate MA or in multi-agent environment where multiple MAs want to locate each other. Mailbox based communication mechanism has been proposed among the MAs and successfully modelled by using CPN tool. Everyone methods projected in this paper talks about the hypothetical, behavioural and psychoanalysis aspects of the location management mechanisms. HLMS has been successfully modelled by using CPN and checked for its validity and correctness. This work simulates the model for different cases and analyses the performance of the HLMS for different parameters. Comparative performance of HLMS with AU and SBP approach is our future goal.

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